Enhancement of Energy Storage Capability of Pure Electric Vehicle using Hybrid Energy Storage System

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna International Institute of Research and Studies

(Deemed to be University)

by

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17/ Ph.D / 055

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Certificate

I hereby declare that the short synopsis *"**Enhancement of energy storage capability of Pure Electric Vehicle using hybrid energy storage system**"* being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy In Engineering under faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2019-20

It is a bonafide record of original work carried out under the supervision of Dr Leena.G and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

Increasing air pollution, depleting petroleum resources, global warming are now the problems of paramount concerns. The use of large number of vehicles on roads has caused serious environmental pollution. Electrical Vehicles provides an immediate solution for eliminating tail pipe emission. Pure electrical vehicles mainly use battery as energy storage system. The battery has to tolerate high power demand and frequent discharging and charging cycle, which obliterate its condition, moreover it has limited range in a one go. So, the solution lies in using two different type of energy storage system, one having high energy density i.e. battery and other having high power density i.e. superconducting magnetic energy storage device. One of the main challenges of using two different types of energy storage system is to design an energy management controller for real-time implementation which target to maximize overall efficiency, performance and reduce pollution. The model of electrical vehicle is simulated in Matlab/simulink using fundamental vehicle kinematics. Firstly the vehicle is simulated using battery alone and this existing simulated model is modified by incorporating super magnetic energy storage device. The power energy split management is done by using both online and offline optimized artificial intelligence technique. The data required for the offline technique is taken from different standard driving cycle. These driving cycles provide the information regarding the velocity of vehicle with change in time. This information acts as input for offline technique and the result obtained from offline computation technique will be feed as input for online technique, which will act as a filter to allocate high frequency demand to the superconducting magnetic storage device and low frequency demand to the battery.

Key words: SMES(Superconducting magnetic energy storage) , EV(Electric vehicle) , HESS (Hybrid Energy Storage System)

CONTENTS

S. No.	Description	Page No.
1	Introduction	1-2
2	Literature Review	2-4
3	Gaps identified	5
4	Motivation	5
5	Description of topic	5-6
6	Objectives of the research	7
7	Methodology to be adopted	7
8	Expected Outcome of the Research	7-8
9	Proposed time frame	8
10	References	9-11

1.INTRODUCTION

Vehicle plays a vital role in human's life. Conventional vehicles uses renewable energy sources like petroleum, diesel ,gas etc. to drive the wheels but these sources are limited in nature moreover it causes lots of pollution. So, the solution lies in depending upon other types of vehicles for example pure electric vehicles, plug in hybrid vehicles and hybrid electric vehicles, etc. These types of vehicles uses electrical energy for its propulsion. As the present development advocates, these means of transportation is likely to substitute internal combustion vehicles in nearby future. According to the report by Autocar India, an automobile magazine, the sale of four-wheeler Electric Vehicles rose to 3,600 in Financial Year 2019 from 1,200 in Financial Year 2018 and the sale of two-wheeler electric vehicles spiked to 126,000 in FY2019 from 54,800 in FY2018.

The advantages of electric vehicles are zero tail emission, trim down green house effect and low running cost of about Rs 0.78 per km. The electrical energy can either be taken from overhead system or from battery. Most of the electric vehicles have limited range in a single charge as these vehicles uses only one energy storage system i.e. electric battery. The chemical property of battery doesn't allow rapid charge and discharge which reduces its life cycle, efficiency and degrade its performance. In order to overcome these problem there is a need for hybrid storage system combining both types of storage system i.e. one should have high energy density (battery) and other should have high power density(superconducting magnetic storage device). The battery used in electrical vehicles have high energy density i.e. they can store large amount of energy but have low power density i.e. they take time for charging and discharging. On the other hand the superconducting magnetic energy storage (SMES) acts as power buffer, which delivers large amount of energy in a very less time i.e. it has high power density. The Superconducting magnetic energy storage device stores energy in superconducting coil in magnetic form, when DC current flows through it. This coil is cryogenically cooled below its critical temperature. Since it stores energy in electrical form only so, it does not need conversion from one form to

another resulting in very high efficiency of around 98 percent. It takes very less time in charging and discharging, which makes it ideal for accelerating, braking and starting process

The model of electrical vehicle is simulated in Matlab/simulink. Here two different systems are considered and their performance analysis is done. The first system uses only one storage device i.e. battery and second system uses the combination of both battery and superconducting magnetic storage device.

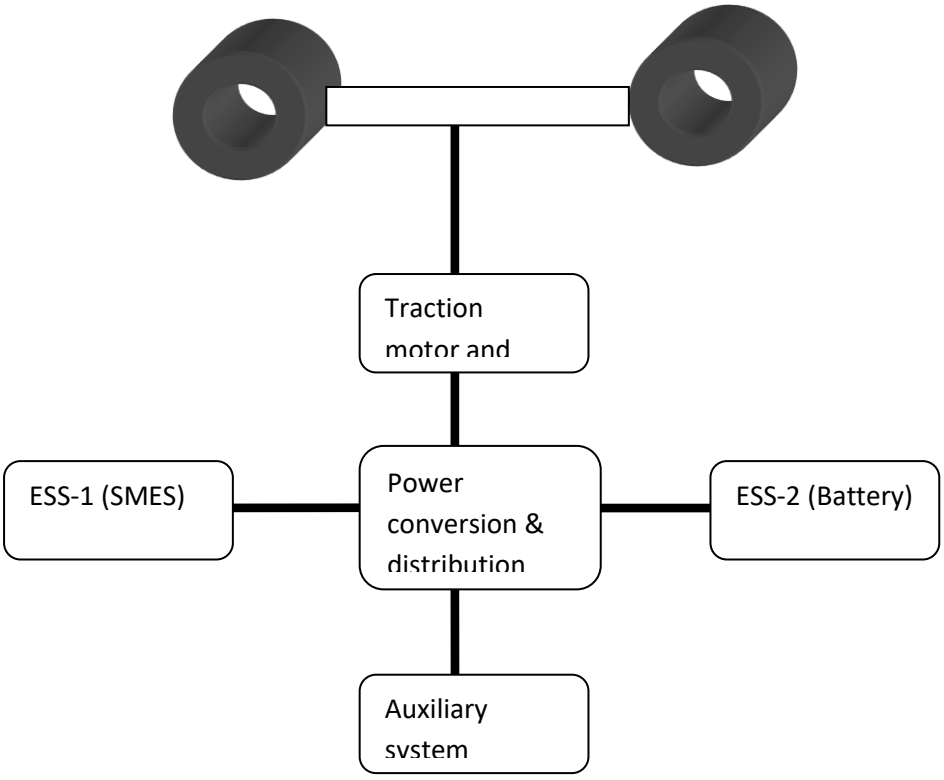

Fig 1. Electrical vehicle with two different energy storage system

2. LITERATURE REVIEW

According to researcher Jain (2018) rising air pollution and increase in energy consumption is the main concern and the key solution for that is the development of electric vehicles. The electric vehicles initiative (EVI) is the multi government policy which is totally focused on accelerating the improvement and implementation of the electric vehicles all over the world.

The electric vehicle requires energy storage device to store energy. Most of the electric vehicles depends upon battery for its propulsion but according to researcher lu, Hua, Jianqiu, Han(2013) for long run period battery possess certain issue and we cannot simply rely on batteries, which provided the impulsion to develop some innovative solutions, moreover as stated by investigator Divya, Østergaard (2009) because of frequent start, stop ,acceleration, deceleration and braking processes, the batteries in electric vehicles are required to meet up the immediate power requirement resulting in regular charge/discharge cycles which will diminish its life.

As the single storage device cannot fulfil all the requirement of electric vehicle. To overcome this issue the researcher Cao, Emadi(2012) incorporated heterogeneous energy storage system(ESS), consisting of ultra capacitors and battery pack in electric vehicle(EV). The comparative analysis for different energy storage technologies for high-power applications was done by investigator Farhadi, Mohammed (2016). In his research paper he also presented advantages and disadvantages of different energy storage system for different power applications. The fuzzy logic management strategy implemented on train by researcher Serkan, Khaligh (2014) which consist of battery-ultra capacitor (UC). With this proposed hybrid energy storage system energy and power density of the EV can be increased, vehicle performance can be enhanced and battery functioning duration can be prolonged. ,According to Dougal,Liu, white (2002) the choice of energy storage system (ESS) depends on the desired characteristics of the vehicle, cost ,its mass and efficiency desired. From knowledge of the characteristics of battery and super-capacitor these both are chosen as energy storage devices. In case of super-capacitor the voltage of each cell is limited to 2.3 to 3 volts so, these are connected in series to produce high voltage but it will result in reduction of total capacitance

The investigators Morandi, Trevisani, Negrini, Ribani (2012) investigate, the feasibility of SMES for hybrid vehicles with cryogenic fuel tank. The performance of analysis is done in MATLAB / Simulink simulation model. After deep study and investigation it is found by Sahoo, Mohanty (2015) that SMES is the best option for electric vehicles. The energy flow in the electric vehicle(EV) make use of information such as GPS coordinate , driver history and internet-available services such as traffic data. The battery losses are reduced by 57.69%, and range increase of 12.53% is achieved by using hybrid energy storage system. It is found by the author Lin, Lei (2017) that superconducting magnetic energy storage device (SMES) have a

very high power density, whereas battery (Li-ion) provides a high energy density (Wh/kg) so different control strategies for hybrid energy storage systems (SMES and battery) is studied and fuzzy control theory was proposed to accomplish an efficient grid connection for a wind farms and this effectiveness of the proposed strategy is verified through simulation studies .Stability analysis of DC power systems in an electric ship using hybrid SMES-battery is done by authors Alafnan, Zhang, Weijia, Jianweii, Elshiekh(2018)

Different control algorithms and energy management strategies have been considered to realize the combined operation of hybrid energy storage system. In year 2014 Hredzak .Jang , Agelidis (2014) introduced a model predictive control(MPC) strategy to limit the battery current. Li (2015) proposed a power management strategy for SMES- battery system. All different types of controller studied so far have a same basic strategy i.e. the controller facilitate as a filter to dispense the power demand as the low-frequency component to the battery and the high frequency component to the SMES or super-capacitor

Since the performance over different drive cycles data under real traffic condition is needed so that the net tractive power required by the electric vehicle and power required by each components of the system has been calculated by Shah, Pritesh, Sagar, Maheshwari (2011).The detailed analysis is done in Labview.

For policy making and future research work the Pfriem, Gauterin (2016) developed three different driving cycles for electric vehicle which utilize empiric data from a large-scale field operational test called project CROME

A Case Study on state highway no 82 was done by investigator Maurya, Bokare(2012) for understanding Real World Indian Driving Cycle .The speed-time data of 114 buses was recorded using Global positing system

The author Marina,Hu(2017) have studied different energy management strategies and found that fuzzy and neuro fuzzy techniques aims to provide maximize efficiency and minimum fuel cost and also author Pedro, M´enard , Marc-Andr´e , Trov˜ao (2017) finds the fuzzy logic controller as best controller for energy and power management for heterogeneous type energy storage system for a three wheel Electric Vehicle (EV) on other hand for improving fuel

economy of EV the researcher Chen MiChunting, Xu, You(2014) proposed neural network with dynamic programming controller as an intelligent energy management system

3. GAPS IDENTIFY

Most of the existing electrical vehicles use only one energy storage system which cannot fulfil all the requirements of the electric vehicles. Mostly electrical vehicles run on battery only so its range is quite limited. Since the batteries used in electric vehicles are subjected to regular charging and discharging cycle but the chemical characteristics of batteries does not tolerate this rapid changes without severe thermal rise, which leads to early failure and limited lifecycle of the battery. So, the most promising solution is to use hybrid energy storage system.

The main concern in electric vehicles with different energy storage systems is managing the energy disbursement, that is , the proportional energy and power splits and establishing methods to interface between two different types of energy storage systems so as to meet the required propulsion and auxiliary load demand To ease battery high power stresses, peak power buffer is required. With latest development in power electronics devices the superconducting magnetic storage device (SMES) is a competing peak electrical power device.

4. MOTIVATION

This research is inspired by the fact increasing price of petroleum based fuel, depleting natural resources and environmental pollution provides compelling thrust towards the development of some eco-friendly solution . So the solution lies in using electric vehicles, which uses electric energy to drive its wheel. Now, the problem with these electrical vehicle is that it mostly uses only one kind of energy storage system i.e. battery which has limited operating range. So, hybridizing two different types of energy storage devices (one with high energy and one with high power density) is the key solution.

5. DESCRIPTION OF TOPIC

Electric vehicle used so far use only one energy storage device i.e. battery, which limits its working range. So, solution lies in using more than one energy storage system(ESS) ,having

high energy and power density. The main challenge now is the power energy management between the two energy storage device. i.e. we need the information that at which instant SMES will work and at which instant battery will drive the wheel. For this an optimization methods and artificial intelligence technique is required.

The input for the system is data is taken from driving cycle. Driving cycles are data point of velocity versus time. The driving cycle is a progression of vehicle performing conditions i.e. acceleration (increase in speed), steady state (const. speed) and deceleration (decrease in speed) with respect to time for a required area. The new vehicles developed are tested on these standard driving cycles.

The approach is to firstly find out the power and torque requirement for electrical vehicle and then design the energy storage system based on it. The main issue is to simulate a real-time controller that can achieve adaptability to the real road condition and which can reduce pressure on battery.

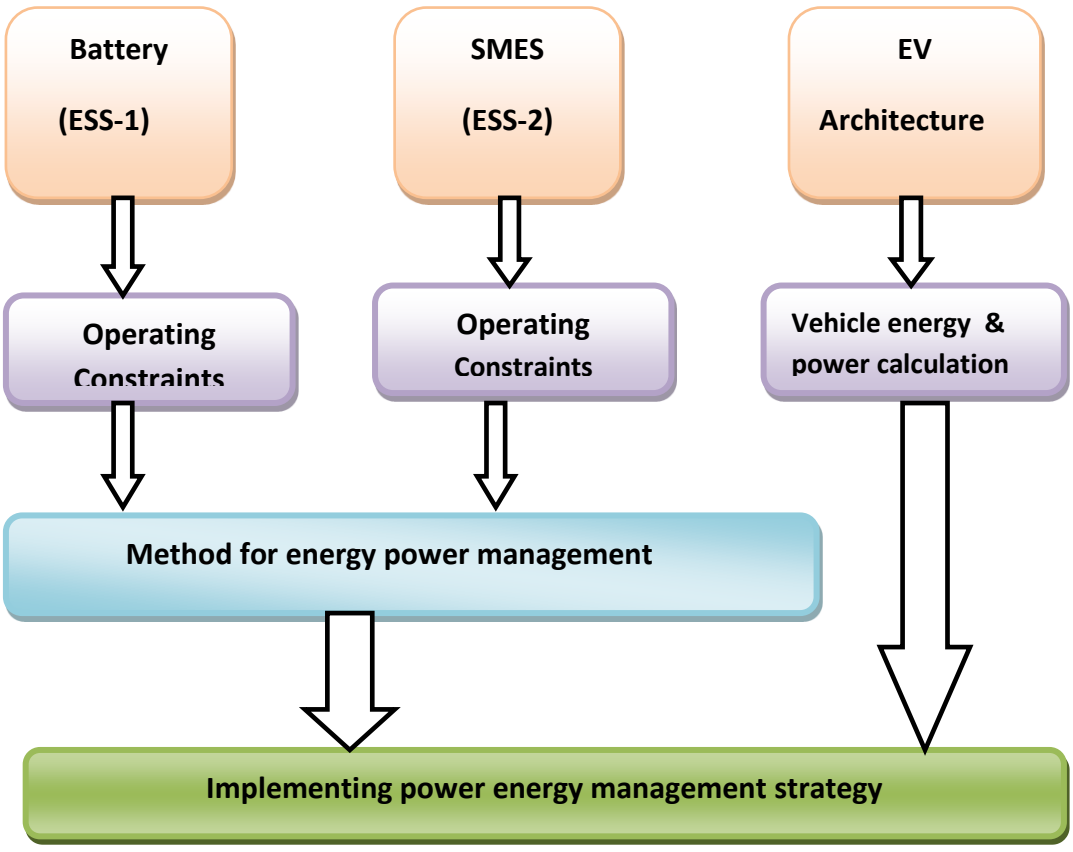

Figure 2 :Flow diagram of EV having SMES and Battery

6. OBJECTIVES OF THE RESEARCH

1. To review different Energy storage system that can be used in electric vehicles.
2. To modify the existing Electrical Vehicle energy storage system.
3. To successfully simulate Electrical vehicle with Li-ion battery in the Matlab
4. To implement integrated model of SMES and Li-ion battery and to develop algorithm for energy management for power spilt in Electric vehicles using these two energy storage devices
5. To develop online intelligent controller for enhancing energy storage capability of pure electric vehicle.

7. METHODOLOGY TO BE ADOPTED

The existing energy storage system used in electrical vehicles is reviewed intensely. Data will be extracted from driving cycle curves. Modelling and simulation of electric vehicle using batteries will be done in Matlab. Then the same system will be simulated with hybrid storage system i.e. battery and SMES. By using artificial intelligence technique the power–energy split management will be done. The filtration based controller will be developed and according to this principle, the low frequency power demand to is allocated to the battery and high frequency demand power will be allocated to the superconducting magnetic storage device(SMES) . The optimal control technique for implementing the offline optimization for the instantaneous power and energy allocation of hybrid energy storage system under various types of driving cycles will be selected and then depending on these optimized result artificial intelligent technique will be applied. At last comparison analysis of two systems i.e one with battery and other with battery and SMES will be done.

8. EXPECTED OUTCOME OF THE RESEARCH

The proposed outcome of the research should produce economically and technically reasonable option for future transportation systems. The research work will explore the possibility of simulating two different kinds of energy storage device and this simulation has to be done with a purpose of reducing the overall weight and price of the vehicle and still fulfill the maximum power requirements of the vehicle.

The proposed electrical vehicle will recover energy during deceleration instead of dissipating it in friction braking. The target of energy and power management system for SMES-battery powered electric vehicle is to meet the efficiency expectations of electric vehicle user and to minimize the losses such that it optimizes the overall system efficiency

9. PROPOSED TIME FRAME

Time Frame	Dec17-June18			July-Dec 18			Jan -June 19			July-Dec 19			Jan-June 2020			July-Dec 20			Mar 2021		
Months	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	37	38	39
Course Work																					
Extensive Literature Survey																					
Problem Statement																					
Data collection																					
Simulation of Pure electric vehicle																					
Simulation of Electric vehicle with SMES																					
Develop and Analyze offline controller																					
Develop algorithm for Optimum power allocation between two energy storage system																					

Research publication																				
Detail Writing and submission report																				

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by Deepali 1 Puri

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